PRIVATE AND CONFIDENTIAL

ENGINEERING DIVISION

Visit to N.V. Philips, Gloeilampenfabrieken, Eindhoven

15th to 17th January 1964

VISIT REPORT No. A-082

1964/10

THE BRITISH BROADCASTING CORPORATION

PRIVATE AND CONFIDENTIAL

ENGINEERING DIVISION

VISIT TO N.V. PHILIPS GLOEILAMPENFABRIEKEN, EINDHOVEN

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D.R. Morse (Planning and Installation Department) (D.R. Morse)

C.B.B. Wood (Research Department) (C.B.B. Wood)

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1. INTRODUCTION

The visit to Philips was arranged primarily to discuss the technical performance of the plumbicon camera tube and to discover the manufacturer's production plans for the tube. It was also considered important to ascertain what progress is being made with improved versions of the tube, particularly to achieve adequate monochrome reproduction of red information in the scene.

If the outcome of these discussions is judged to be sufficiently promising, it is the BBC's intention to gain experience of the plumbicon by putting into service two lightweight outside broadcast monochrome cameras employing this tube, and therefore the second main purpose of the visit was to discuss the provision of suitable camera channels. A draft BBC specification[1], TV/142, had been prepared and copies of this, together with a draft Research Department report[2] on the measured performance of the plumbicon camera tube, had been sent to Philips in advance of the visit.

The opportunity was also taken to discuss briefly the colour application of the tube and Philips' plans for the development and manufacture of plumbicon colour camera channels.

2. GENERAL

The Philips' organisation comprises thirteen Main Industry Groups, which together cover the whole range of the company's activities. These Groups have many associated companies in other countries concerned with the sale and, if desirable, local manufacture of their products. The Groups with which our visit was concerned were:

1. The Research Laboratories
2. The "Electronica" Group
3. The Electro-Acoustics Group ("ELA")

The Research Laboratories undertake all basic research but when a new device reaches the stage of commercial development it is handed on to the appropriate manufacturing Group. The Electronica Group handles valves, cathode-ray tubes, camera tubes and transistors and the standard plumbicon tube is now in their hands, undergoing the final stages of development for quantity production during 1964. The red-sensitive plumbicon tube is, however, still entirely a Research Laboratories' project and seems unlikely to move on to the Electronica Group in the very near future.

The ELA Group was originally concerned only with professional cinema apparatus, sound recorders and amplifiers, but their activities now include television programme-origination equipment. They have a fairly large section working on television cameras for various applications but their experience in this field is not particularly wide and extends only over the last five years.

3. DISCUSSIONS WITH ELECTRONICA ON 16TH JANUARY 1964

Present: Dr. J.D. Stephenson (Assistant Technical Director, Electronica)
Dr. E.F. de Haan (Assistant Technical Director, Research Laboratories)
Dr. D.W. Kuhl (Head of Camera Tube Development, Electronica)
Ir. J.R. Boerman (Camera Tube Measurement, Electronica)
Mr. J.W. Bosboom (Commercial Assistant Professional Tubes, Electronica)
Mr. J. Dollekamp (Technical/Commercial, Camera Tubes, Electronica)
Mr. J.V.S. Tyndall (Manager, Electron Optical Devices, Mullard Ltd.)
Mr. J.E. Wilson (Sales Engineer, Electron Optical Devices, Mullard Ltd.)

3.1. Technical aspects

Dr. Stephenson summarised the general position on the plumbicon tube by saying that the programme of development and limited manufacture which Philips had followed in the last year was directed at confirming the findings of their Research Laboratories and at making tubes available for assessment by prospective users. During the coming year they aim to engineer the plumbicon in a form suitable for manufacture and to set up the means of manufacture. On the marketing side, potential users will be supplied with tubes for the development and pilot production of plumbicon cameras. In short, Philips' activities during 1964 will be directed at giving prospective users confidence to commit themselves to the use of plumbicon cameras on a reasonable scale in 1965.

Dr. Stephenson stated unequivocally that Philips intend to go ahead with manufacture of the plumbicon and will guarantee the continued supply of tubes to any user who invests in camera equipment.

Philips appeared particularly grateful for the draft BBC report and it seemed that they were setting some considerable store on the BBC's views.

The BBC's attitude to the plumbicon tube was then stated. Mention was made of the very careful investigations that had been carried out in 1956 and 1957 before deciding on the camera tube to be used in Television Centre. The decision to use the $4\frac{1}{2}$ in. image orthicon was eventually taken because of the superior picture quality obtainable, and since that time many improvements had taken place in the performance of the tubes and the associated cameras. We were, therefore, accustomed to a very high standard of picture quality and in considering any new camera tube it was inevitable that comparisons would be made with the $4\frac{1}{2}$ in. image orthicon. The simplicity and the small size of the plumbicon were most attractive as was its higher sensitivity in comparison with the image orthicon, but none of these advantages concerned the viewer and it was essential that there should be no significant reduction in transmitted picture quality. At the moment, it therefore seemed that the application of plumbicons to black-and-white television would necessarily be restricted to certain types of programme in which the known shortcomings of the tube would not be obvious.

Dr. Kuhl said that at the moment Philips regarded the plumbicon tube as being principally suitable for use in colour television cameras but that it would have enough advantages to be valuable in many black-and-white applications. The advantages of the tube were that it had a stable black level, there were no re-distribution effects and the triangular spectrum of the noise was more acceptable than that of the image orthicon. The disadvantages were that the light-transfer characteristic was completely linear and the tube might, as a result, encounter difficulties for outside broadcast work because of the high peak-brightnesses which are encountered. Furthermore, the sharpness of the picture produced cannot, at present, compete with that of the $4\frac{1}{2}$ in. image orthicon. On colour response, Dr. Kuhl referred to the "excessive red sensitivity of the image orthicon" and indicated that Philips regarded the present colour response of the standard plumbicon as rather desirable.

In order to discuss the properties of the plumbicon tube in a systematic manner, it was decided to go through the draft BBC report and deal with each parameter in turn.

Resolution

The resolution measurements made by the BBC (30% - 40% response at the upper limit of the video band) were agreed to be typical for the plumbicon tube in its present state of development. Loss of resolution in this tube is known to have three principal causes:

(i) Light scatter in the lead-oxide layer before final absorption.
(ii) "Hole" scatter in the region of weak field within the semi-conductor layer.
(iii) Aperture distortion by the scanning beam.

Dr. de Haan said there were strong possibilities of an improvement in resolution by modification of the semi-conductor material to reduce optical scatter in the target layer. Secondly, an improvement might be obtained by the use of a thinner target, although this might be at the cost of some sensitivity, and possibly some increase in lag. Philips indicated that they believe they have not yet settled on the optimum thickness and characteristics for the target having regard to all these factors. They expected, however, that any improvements in resolution in the near future would be of a marginal nature.

Discussion took place on the possible advantages of operating the plumbicon with a separate field mesh, since this technique has been shown to give a considerable improvement in resolution for the vidicon tube.[3] Philips were of the opinion that any improvement in resolution with detached-mesh operation can be expected to be much less for the plumbicon than for the vidicon because the principal loss of resolution is due to the target layer and not to the electron-optical system.

It was, however, recognised that detached-mesh operation can confer further advantages in respect of freedom from the effects of excessive beam current and the reduction of beam-landing errors. Philips' Research Laboratories are at present repeating an earlier investigation to determine to what extent these advantages might be realised for the plumbicon. They pointed out that the beam-landing error with the latest design of yoke is small and it is therefore considered that there may be little to be gained in this respect. The possibility of avoiding the effects of the use of excessive beam current is, however, regarded as important.

Philips undertook to make detached-mesh plumbicons available to the BBC for measurement.

The effect of the scanning yoke upon resolution was also discussed. The original yoke with which we had made our initial measurements

had been found to have a beam-landing error* of no less than 5 V. A second yoke design reduced this to less than 0.5 V but this yoke had considerable curvature of the focal plane. A third version of the yoke was now under construction and was claimed to give substantially equal resolution in the centre and corners of the field.

A novel technique for the alignment of the tube was described and later demonstrated. The procedure is to set the target potential to a very low value (in the range 0 V to 3 V) and then to increase it slightly until a faint picture is observed. Adjustment of the alignment current is then carried out for uniformity of picture modulation over the field, i.e. for maximum flatness of the beam-landing characteristic. The tube is then restored to normal target potential, which should be 45.0 V unless it is absolutely necessary to work at a slightly lower voltage to avoid the visibility of white-spot blemishes which sometimes occur in the present tubes.

Dr. Kuhl raised the question of modulation depth and suggested that subjective sharpness was a more valuable indication of tube performance than percentage modulation at a certain spatial frequency. Because the shape of the modulation-transfer characteristic is usually very similar in all camera tubes, we thought that either method of assessment gave approximately the same indications.

As an additional development, Philips are considering the possibilities of a larger plumbicon (40 mm diagonal, say) to improve the intrinsic resolution. They are, however, concerned that some of the advantages of the present plumbicon might be lost in a larger version of the tube.

Colour response

There had already been indications of some divergence of opinion on the present colour response of the plumbicon tube. Whereas Dr. Kuhl and Dr. de Haan had spoken of the "excessive red sensitivity" of the image

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* Beam-landing error is defined as $V_m \sin^2\theta$

where V_m = potential of the mesh with respect to the cathode

θ = angle to axis at which the electrons pass through the mesh.

It is the potential representing the lateral energy of the electrons due to imperfections in the focusing-deflecting yoke. See: Castlebury, J., and Vine, B.H., "An Improved Vidicon Focusing/Deflecting Unit", Journal of the S.M.P.T.E., Vol. 68, No. 4, April 1959.

orthicon, the BBC's experience has been that this tube has a colour response which is very near to optimum for monochrome television. The standard plumbicon is virtually blind at 640 nm, and this is significantly worse than the response of the old C.P.S. Emitron and P.E.S. Photicon tubes, neither of which was regarded as very satisfactory from the colour response point of view. Philips were told that the present colour response of the "standard" plumbicon, in the opinion of the BBC, made it unsuitable for studio use and only tolerable for outside broadcast application. Were the BBC to invest in the plumbicon outside broadcast cameras under discussion, it would be in the expectation that an extension of red response would be secured in the fairly near future.

Philips were reluctant to accept that the red response of the present tube is unsatisfactory for monochrome use, although they volunteered the statement that an extension of red response is important for colour applications. They conceded, however, that they had not undertaken any thorough or extensive investigations to determine the optimum colour response of a monochrome camera tube, such as those conducted by the BBC Research Department,[4] which were discussed.

Dr. Kuhl suggested that the difficulties of the plumbicon response in studios could be overcome by the adoption of new make-up techniques, and instances were quoted in which satisfactory monochrome rendering had been obtained with the plumbicon tube. We did not, however, favour this suggestion, because of the difficulties of having to vary make-up practices according to the type of camera tube to be used. Furthermore, the lack of red response could not be compensated in televising outside scenes of people and places. Philips made it clear that, in view of their production plans for the tube, it would not, in any event, be practicable to consider any change in the plumbicon colour response being introduced in under one to two years from now. It seemed fairly evident that apart from Philips' reluctance to agree to any change in the tube specification which would delay manufacture, they are also conscious of the research and development problems involved. Dr. de Haan indicated that he had, in fact, only one skilled worker who could reliably make red-sensitive tubes in the research laboratory and there was considerable work to do before this could be translated into a quantity production programme. At the moment, the tube development engineers are fully occupied in commissioning their new quantity-production facilities, and it would be unreasonable to suppose that any large effort could be directed to solving the problems of the red-sensitive tube until the current tasks have been completed.

We stressed the desirability of an improvement in the red sensitivity of the tube as a most important objective. This is a matter which requires further discussion and the BBC undertook to provide Philips with copies of the Research Department report[4] already referred to.

Sensitivity

The sensitivity measurements made by the BBC were regarded by Philips as being typical of their present production. It was agreed that the sensitivity of the standard plumbicon (roughly twice that of the medium-spaced $4\frac{1}{2}$ in. image orthicon type P822 for the same depth of field) is very satisfactory, and any changes (such as reducing target thickness to increase resolution) which reduced the sensitivity were not really to be recommended. A further increase in sensitivity should be achieved when, as we hope, the red-sensitive tube eventually becomes available.

Signal-to-noise ratio

It was agreed by Philips that our choice of peak signal current of 0.3 μA was a reasonable value for the tube and suitable for the specification of signal-to-noise ratios. The actual value of signal-to-noise ratio achieved with any given tube is determined largely by the excellence of the head amplifier in the camera. The degrees of gamma correction and aperture correction necessary are, however, determined by the tube characteristics and while there is no likelihood of a change in the light-transfer characteristics of the plumbicon tube, there is hope that new photo-conductive layers may have higher resolution and hence require less aperture correction. This, in turn, will improve signal-to-noise ratios in the upper video frequencies; a particularly important point for colour television applications.

Lag

The lag of the standard plumbicon tube is very small and gives very acceptable portrayal of movement under normal lighting conditions. Both capacitive lag and photo-conductive lag are present, although Dr. de Haan thought that in this tube the former makes the greater contribution. He also mentioned that capacitive lag is a function of the current flow in the target and that it is very difficult to separate its effect from that of photo-conductive lag. An increase in target volts reduces both forms of lag, and at present it is believed that the tube should be operated at not less than 45 V target potential for optimum performance. It was agreed that the present experimental red-sensitive tube had significantly longer lag but there were many variables involved and it was by no means certain that a bad lag performance would have to be accepted as the cost of improved red response.

There was an interesting discussion on the relative importance of long-term or short-term lag characteristics. Philips were convinced that the number of fields required for a peak-white signal to be reduced to mid-grey was a more important factor in producing "trailing" of a moving object

than the number of fields required to reduce the same signal to less than, say, 1% peak white. They quoted their experience in the field of X-ray image intensification, where they have found that signal information at a level of about 1% provides inadequate contrast to be useful. It was, however, agreed that the lag characteristic of the present red-sensitive plumbicon tube would not be satisfactory for all television broadcast purposes and that further work was desirable to determine the maximum permissible lag for satisfactory movement portrayal.

"Sticking"

The "sticking" observed in certain tubes so far examined was not regarded by Philips as being very important. Improved production methods would reduce the number of tubes which failed to respond to the normal ageing process. A new tube is very subject to this effect, but it gets less with use and normally disappears after 50 hours' life. Provision is made in the new production facilities for all tubes to be aged for 50 hours before the final test procedure.

Gamma

The principle of operation of the plumbicon tube is such that it will inevitably have a linear light transfer characteristic. For studio colour cameras, this is very desirable, but for outside broadcast black-and-white transmissions, there is a hazard due to very high contrast scenes causing overloading of the tube. Under conditions where extremes of brightness are encountered, the plumbicon is more likely to suffer adverse effects from over-exposure than is a tube of lower gamma. In severe cases, increased lag could occur where there was insufficient beam to discharge very bright areas of the picture; there will be an increase of the image size of highlights and sticking and beam "bending" could also be experienced. Highlights may also give rise to "burning-in" if the camera has been exposed for any length of time to a very bright object. These are partly problems of camera design and partly problems of operating techniques. It was concluded that these hazards could only realistically be assessed as a result of practical experience, but the freedom from "excess-beam" defects, which detached-mesh operation might give, could be of great benefit in making it possible for the beam current to be increased sufficiently in some cases to discharge excessively bright areas of the target.

The "peel-off" effect

The "peel-off" effect mentioned in our draft report had interested the Philips' engineers but they could offer no explanation for the effect, neither had they ever seen it for themselves. They were sure that it was

a peculiar fault condition associated with only a few tubes and that it in no way represented a serious production problem. Arrangements would be made to recover a specimen plumbicon which had been bought by E.M.I. Ltd. and was known to exhibit this defect.

3.2. Visit to the Electronica Camera Tube Production Plant

We were taken to the factory where plumbicon tubes are being made and were shown the space in which new production facilities are due shortly to come into operation. We were also shown prototype production tubes and the test apparatus used for quality control. There was a small studio in the factory to permit more detailed examination of subjective requirements.

The new production area was obviously planned on a very efficient and comprehensive scale. The pumping stations were being established with centralised supplies and the entire area was to be pressurised with clean air. The test room also showed considerable efficiency in design, much of the apparatus having been constructed specially by the local staff, who were extremely enthusiastic about the prospects of the quantity-produced plumbicon tube. The final test of each tube occupies one man 45 minutes if it is without fault. At the present time, blemishes are the principal difficulty and it is hoped that when the production is transferred to the new, clean area, there will be an improvement in this respect. Electronica intend to mask the target of each tube, leaving unobscured only the correct area to be scanned, but at the present time they find it necessary to retain access to the whole of the photo-sensitive area in order to reduce rejections due to blemishes.

The production prototype tubes shown to us appeared to be very much better engineered than in all the plumbicon tubes we have seen so far. The new tubes have a pre-formed target and a much superior contact ring around the faceplate of the tube. The base is an all-glass construction with sealed-in pins similar to those used in many small valves and the whole tube looks very business-like.

3.3. Future production and marketing plans

Manufacture of tubes is taking place at present with development equipment and the new manufacturing facilities already described are due to be completed during February for operation by the end of March 1964. The impression was given that Philips have set their face against continuing research and development on the tube beyond the stage it has reached at present as a prelude to the start of serious manufacture. They are probably influenced by the fact that so much advance publicity has been given to the plumbicon over a period of several years that to delay manufacture now would revive the scepticism which has been expressed in the past about the tube.

Moreover, the problems of achieving an extended colour response are perhaps such that to link manufacture with this further development could cause an appreciable delay in the availability of production tubes. Officially, Philips say that only non-red-sensitive tubes will be available for use with the colour camera channels which ELA are manufacturing for delivery during 1964.

Philips were asked to provide figures both for their expected output of broadcast-quality tubes from their new production plant and the proposed allocation of such tubes to Mullards, who will be responsible for marketing the plumbicon in this country. Figures were given on the strict understanding that they are only for the internal information of the BBC, since Philips are understandably anxious that none of their competitors should learn of their expected output rates and be able to deduce the capacity of the plant they are setting up. These figures are being given a more restricted circulation than this report.

A positive assurance was received from Dr. Stephenson that, in the event of the BBC purchasing plumbicon cameras, Philips' tubes would be supplied without discrimination whether the cameras were bought from ELA or from any other manufacturer.

Philips have in mind the setting up of a further production plant (not necessarily in Holland) to follow that already described, but it was not possible to obtain a close estimate of when this might come into operation.

Philips have no firm programme to set up plumbicon production in the United Kingdom, but it was said to be general company policy to aim at creating several plants to manufacture a given item. This is partly an insurance against the enforced shut-down of plant as a result of fire or some other cause, and partly because it is felt that better results are obtained with the spur of competition. As far as the United Kingdom is concerned, Philips are fully prepared to consider setting up plumbicon manufacture. Whether they will do so depends on the demand for tubes but they recognise that political reasons could compel a prospective user to insist on the provision of local manufacturing facilities as a necessary condition of the wide adoption of plumbicon cameras.

A positive statement was also made that it is not Philips' policy to try to keep a monopoly of the plumbicon tube, and indeed the possibility of manufacture by another company under licence is currently being discussed.

Mullards are fully prepared to consider either the outright sale or the hire of plumbicons to the BBC, although they showed some preference

for a hire agreement initially to be followed by purchase at a later date when the manufacturing quality and a specification for the tube had both been stabilised.

At the present, tubes are being sold outright to the BBC at £325 each, and there is no indication that this price will be reduced in the foreseeable future. No guaranteed life figure has yet been firmly adopted, but Philips spoke in terms which suggested that this would not be less than 500 hours.

4. DISCUSSIONS WITH ELA ON 15TH AND 17TH JANUARY 1964

Present: Ir. J.J.P. Valeton (Head of Camera Equipment Development, ELA)
Mr. Seur (Camera Equipment Development (Monochrome), ELA)
Mr. C.B. van de Panne (Article Manager, Camera Equipment, ELA) (part-time)
Mr. Rosulek (Commercial/Technical, Monochrome Cameras, ELA)
Mr. E.W. Penfold (Development Manager, Peto Scott Electrical Insts.)
Mr. D. Egan (Deputy Commercial Manager, Peto Scott Electrical Insts.)

Peto Scott Electrical Instruments of Weybridge, Surrey, is now a wholly-owned subsidiary of Philips in the U.K., the holding company of which is Philips Electrical Industries. Peto Scott, although much smaller (about 400 employees), therefore occupies a parallel position in the organisation structure with Mullards and Philips Electrical.

It is Philips' intention that ELA and Peto Scott shall pursue complementary activities in the field of professional television equipment. At present, Peto Scott are undertaking the development and manufacture of monochrome picture monitors and are developing a monochrome plumbicon camera, deliveries of which are due to start late in 1964. The basic circuit development of this camera was done in Eindhoven, and ELA are keeping a close watch on the project and appear to regard themselves as ultimately responsible for its success.

It was explained that the BBC has an urgent operational requirement to provide two lightweight camera channels for outside broadcast use. The present colour response of the plumbicon tube did not appear to be satisfactory for applications where facial skin tones might figure largely in the scene and the requirement for outside broadcast cameras presented a good opportunity to use the plumbicon in its present form and to gain experience with it in the hope that improvements in the tube would follow in due course.

The BBC had, therefore, produced a specification (No. TV/142) for plumbicon outside broadcast camera equipment, copies of which had been sent to Philips for study in advance of the meeting. This specification had also been discussed briefly with Peto Scott.

It was made clear that the BBC's interest in plumbicon camera equipment must be conditioned by both the technical performance specification and Philips' production and marketing plans for the plumbicon tube.

We also made it clear that if the discussions on the plumbicon tube are regarded as having a satisfactory outcome, the purchase of associated camera equipment will be covered by the Corporation's normal tendering procedure, in which a number of manufacturers will be invited to submit quotations.

Specification TV/142 had been made as complete as possible so as to make quite clear both the standard of technical performance and the operational facilities at which the BBC are aiming. It was, however, emphasized that early delivery of equipment is extremely important and any proposals that Philips might make to meet the essential requirements by possibly adapting a photo-conductive channel of existing design would be of interest.

There appeared to be a number of possibilities for the rapid production of television cameras containing the plumbicon tube. One of these was the ELA H-Q camera, which was originally a closed-circuit vidicon device. It is completely transistorised, has gamma correction, aperture correction and the scans are locked to a pulse generator. This camera, modified for plumbicon operation, was later demonstrated and although extremely neat in design, it was felt that the general concept was not sufficiently elaborate to form a useful solution to our requirements. The camera itself was about 12½ in. x 7 in. x 4 in.; a separate camera control unit and also a power unit/pulse generator were of about the same size. The picture quality was reasonably good, but in many respects the apparatus was a long way from meeting the specification which we have laid down. Nevertheless, the North American Philips Co. are modifying a number of H-Q cameras for supply to C.B.S. and it will be interesting to see how well this small camera performs in service.

Another possibility was based upon the modification of an existing design. This was the X-ray image-intensification camera, formerly a vidicon project, and now re-designed for the plumbicon. This apparatus gave the impression of being of much better quality than the H-Q camera, and took the form of a cylindrical camera about 4 in. in diameter and 10 in. long, excluding the lens. A camera-control unit, pulse generator

and power supply were contained in a single 19 in. rack-mounting unit which was about 10 in. high and 15 in. deep. The controls for this camera had been made extremely simple so that it could be operated by a radiologist without the services of a technical operator and this apparatus showed some promise of development into a specialised plumbicon broadcast camera to be used in association with a camera crane such as the Vinten Peregrine.*

Neither of the cameras already described carried a turret and Philips said that they have no photo-conductive camera for early delivery which has this facility. The modified H-Q cameras for C.B.S. were to be followed by a delivery of newly-designed plumbicon turret cameras aimed at meeting a C.B.S. specification. These were being made by Peto Scott at Weybridge. The BBC specification was, therefore, examined point by point in relation to the plans for this camera. Philips expressed the view that the design of camera under development by Peto Scott goes a good way to meeting the requirements of TV/142, and it appeared that this would basically be the camera Philips would offer. In general, therefore, Philips' comments on the specification were in terms of the design targets adopted for this camera.

It is not proposed to include in this report a detailed account of the discussions on the camera specification, which are separately recorded in the form of notes.[5] In general, there was no disagreement about the specification, but the Peto Scott channel as at present conceived would not meet our "ideal" requirements in all respects. However, in discussing a number of points in which it lacked the facilities we require, we attempted to indicate those which were regarded as essential.

We stated that we would report the outcome of our discussions in Eindhoven on the plumbicon to our Management, when a decision would be taken on whether to proceed with the purchase of cameras. If it is decided to go ahead, then formal invitations to tender will be issued by the BBC.

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* The "Peregrine" camera crane being developed by W. Vinten Ltd. for the BBC consists of a small mobile rotating platform, able to move in any direction, supporting a jibbing arm which carries a television camera capable of being raised from a lens height of 1' 6" to 11' 6". Zoom, focus, pan, tilt, height, turntable position, and speed and direction of the complete crane are all controlled by two operators seated side by side upon the base.

The BBC were asked to send any invitation to tender to Peto Scott, but Mr. Egan stated they should feel free, if they desired, to address their enquiry to any part of the Philips organisation.

It was agreed that Philips would conceive their tender in terms of alternative offers giving the facilities and performance to be provided as a function of delivery date.

The BBC said it was important that an early opportunity should be provided of evaluating the Peto Scott production prototype camera. Mr. Penfold considered that a complete working prototype would probably not be available until April/May 1964, but it was agreed that there should be demonstrations of the more important performance parameters as part of any tender negotiations.

Philips undertook to make up-to-date copies of the target specification for the Peto Scott camera available to the BBC within the next month; and also to provide copies of the final specification when measurements have been conducted on the new prototype channel.

5. COLOUR TELEVISION PROJECTS

The main discussions with ELA concerned specific requirements for monochrome cameras. During a visit to the laboratories to view the various projects under development in ELA we were, however, able to see the production prototype three-tube colour camera being developed by Ir. A.G. van Doorn. This new colour camera appears to be a considerable improvement upon that at present in use at Studio H, Lime Grove. It is a little taller than the earlier model and there were two important differences. The first is that the array of three camera tubes, with their associated prism-block optical beam-splitter system is now placed in a vertical rather than a horizontal plane as in the earlier camera. This accounts for the greater height of the camera and the alteration was obviously necessitated by the change in tube layout used with the prism-block optical arrangement. The angle between the axes of the tubes is much greater than that in the old dichroic mirror arrangement and rather than make the camera wider, they have chosen to make it higher. The result is a very clean layout with good accessibility to all components, and the new arrangement of optical components should give improved freedom from colour "tilts" in the field direction.

The second and somewhat surprising difference is that the prototype camera has a turret with a set of five prime lenses specially computed by Schneider of Kreusnach to have sufficient rear-working distance without the necessity for a relay system. The lenses are corrected for the presence of the prism block.

The loss of transmission and lower resolution of zoom lenses are important considerations in such an application, and it is very interesting to note that these special lenses have been developed. It was stated, however, that two potential customers for this camera (C.B.S. and R.T.F.) have expressed little interest in the arrangement and prefer to have a zoom lens.

Some difficulty is being experienced with the mechanical design of the turret. As a consequence of the elimination of the relay system, the turret has to move forward before turning and then drop back into place; smooth operation has not yet been achieved and because of the lack of interest in the turret camera, Philips are considering abandoning it in favour of a zoom-only design.

We did not see this camera in operation, but the general impression gained was that it is a rugged and well-engineered device which looks capable of reliable service. It is fully transistorised and weighs only about 100 lbs., including lenses. The first five of these cameras are due for completion by August and have already been sold. A further five cameras will be completed during 1964. All ten cameras will be produced under model shop conditions as a pilot production run. ELA plan to produce complete manufacturing information for the camera channel during 1964 and to place an order on their factory for a quantity of twenty-five, for which there would be a nine months manufacturing cycle.

We then visited the colour studio in the Research Laboratories where we saw the usual colour demonstration given to visitors, the pictures being derived from an early plumbicon colour camera similar to that which we have on loan. The picture quality was rather less good than we are accustomed to, being noisier and less sharp, but the bandwidth of the NTSC luminance signal was 7 Mc/s. When a 5 Mc/s low-pass filter was placed in the luminance signal circuit, the noise appeared to be reduced, but there was no appreciable change in the sharpness of the picture. It seemed clear that the performance of this colour camera was significantly worse than could be achieved with the most recent designs of scanning yoke and head amplifier.

A short discussion with Mr. Tan, of the Research Laboratories, revealed that they were giving considerable thought to the possibilities of four-tube cameras. For a high-resolution separate-luminance tube, some experimental 2 in. plumbicons had been made and we were shown one of these tubes, although it was not possible to see it in operation. The working area of the target is the same as that of the image orthicon photo-cathode, (40 mm diagonal) so that the optical components of an image orthicon camera would be suitable also for this new tube, which is, however, only about one foot long. Mr. Tan said that the performance of this tube

was so far not particularly good, but blamed much of this on the fact that they had used image orthicon scanning components which were not well suited to the large plumbicon.

The Episcan apparatus was also shown at our request. This is a flying-spot opaque-caption scanner in which the raster is imaged by a wide-aperture lens on to the subject matter. Light reflected from the caption is collected by an integrating sphere of about 10 in. radius which encompasses the front element of the lens, the caption, and the entry to a conventional beam-splitting arrangement with three photo-multipliers. Only flat cards not exceeding about 8 in. x 6 in. may be scanned, but the signal-to-noise ratio was reasonably good.

6. CONCLUSIONS

(i) It is very clear both from Philips' statements and from their production plans for the tube that they intend to pursue vigorously the manufacture and continued development of the plumbicon.

(ii) The red-sensitive plumbicon is still in the Research Laboratories and there are fundamental problems to be solved before production difficulties can be tackled. It seems unlikely that a production version of the red-sensitive tube will be available in less than two years, although a few experimental tubes might be obtained from the Research Laboratories for the red channels of colour cameras.

(iii) Philips' attitude to the colour response of the standard plumbicon is that it is adequate, although admittedly not ideal, given special make-up techniques. This attitude may be conditioned to some extent by the present technical difficulties with the red-sensitive tube.

(iv) The intrinsic resolution of the present plumbicon is disappointing and there is no prospect of anything but a marginal improvement in the near future.

(v) It would almost certainly be necessary to start our operational use of the plumbicon camera with the standard tube.

(vi) There may be some difficulty in using the plumbicon tube for outside broadcasts. High contrast lighting may cause overload of the tube and camera circuits; there is not enough information at the present moment to indicate how serious this

may be. From this point of view, the plumbicon is more suitable for indoor use under controlled lighting conditions, but here its colour response defects are more likely to be obvious because such programmes usually involve close-ups of faces.

(vii) In design intention the monochrome plumbicon camera being developed by Peto Scott Electrical Instruments Ltd. lends itself to meet fairly well our specified requirements for outside broadcast cameras. Our experience with the earlier plumbicon camera produced by this firm must be weighted by the fact that Eindhoven appear to be aware of the need for close technical control of the new camera.

(viii) It is clear that Philips welcome and value the BBC's interest in the plumbicon and wish to extend the co-operation over the tube which has so far taken place.

(ix) Once the BBC invests in plumbicon channels it will be in a much stronger position to influence Philips' development of the tube than if it were to try to do so from the position of an "interested onlooker".

7. RECOMMENDATIONS

(i) Possible difficulties with the plumbicon camera should not be allowed to deter us from going ahead with the project, since the potentialities of the plumbicon tube are very great.

(ii) We recommend that the Corporation proceeds with invitations to Philips (Peto Scott) and to other manufacturers to tender in terms of plumbicon equipment for the two monochrome outside broadcast camera channels for which there is an operational need.

(iii) The production plans for this tube are sufficiently well advanced and the quality control measurements proposed are sufficiently complete to indicate that a supply of good-quality standard plumbicon tubes will be available for the cameras. It is, however, proposed that we should obtain a written and explicit assurance from Mullards that they would guarantee the availability of plumbicon tubes on a scale which we should lay down to serve these cameras.

(iv) When the cameras are put into service, they should be used experimentally in the widest variety of applications that can be achieved. The restricted red response and the rather

doubtful contrast-handling ability of the tube will place certain limitations on the usefulness of the camera and these should be evaluated as soon as possible.

(v) We should continue to collaborate with Philips Research Laboratories and Electronica in measuring and testing experimental tubes since they obviously value the results obtained by others and this, again, tends to strengthen the influence of the BBC on the future course of this tube.

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